THEME 1

Soil organic matter derived CO_2 - Comparison of partition methods from an Acric Umbrisol

Louis-Pierre Comeau, **Derrick Y. F. Lai, Jane J. Cui**

香港中文大學
The Chinese University of Hong Kong

INTRODUCTION

Without accurate data on soil heterotrophic respiration (Rh), assessments of soil carbon (C) sequestration rate (or C balance) are challenging to produce.

When the amount of new organic residues added to the soil is greater than the C lost by soil organic carbon (SOC) decomposition, SOC content increases. However, soil organic matter structure and genesis are not yet fully understood and there are still many uncertainties about the rates of SOC accumulation and decomposition in many ecosystems. These uncertainties are due in large part to the fact that total CO_2 flux (Rs) from soil do not provide the necessary information to assess whether the soil is a net source or net sink for atmospheric CO_2. Specifically, the autotrophic (Ra) part of the Rs does not cause net C losses to the atmosphere because this C is simply cycling around inside the ecosystem. Conversely, microbial respiration (i.e. heterotrophic; Rh) represent C losses (Fig. 1). For the reason that the boundary between Ra and Rh is not sharp (i.e. the rhizo-microbial respiration is linked to both), realistic Rh assessments are difficult to produce.

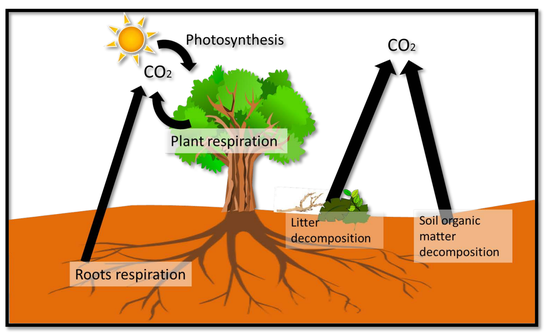

Fig. 1: Auto (left) & Hetero (right) - trophic respiration

OBJECTIVES

The goal of this study was to compare four different partitioning methods to separate CO_2 flux into its Rs and Rh component in a subtropical secondary forest in Hong Kong.

METHODOLOGY

We combined automated chamber measurements of Rs with four different partitioning methods: (1) regression between root mass and root derived CO_2; (2) lab incubations with minimally disturbed soil microcosm cores; (3) root exclusion bags with intact soil blocks; and (4) root exclusion bags with hand-sorted roots. Litterfall and litter decomposition rates were also assessed with decomposition bags to further segregate microbial respiration of dead plant material from soil organic matter (SOM) derived CO_2.

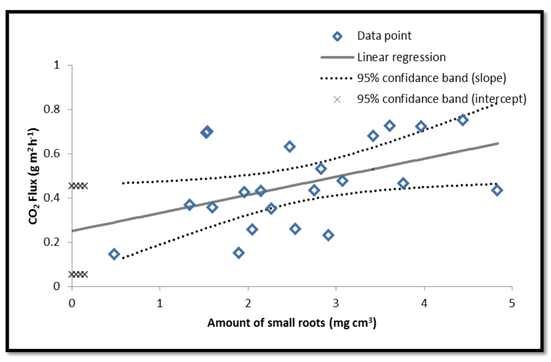

Fig. 2: Linear regression between root quantity and CO_2 flux

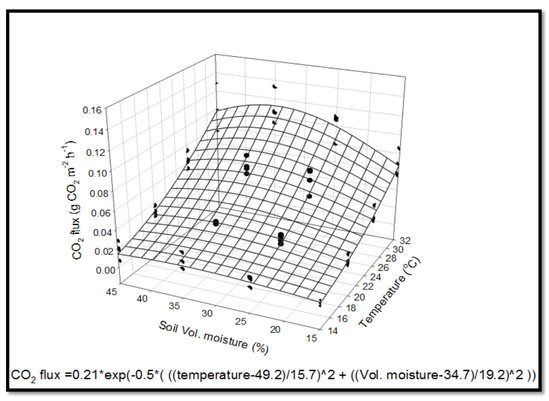

Fig. 3: Lab incubation results: regression between temperature moisture and CO_2 flux

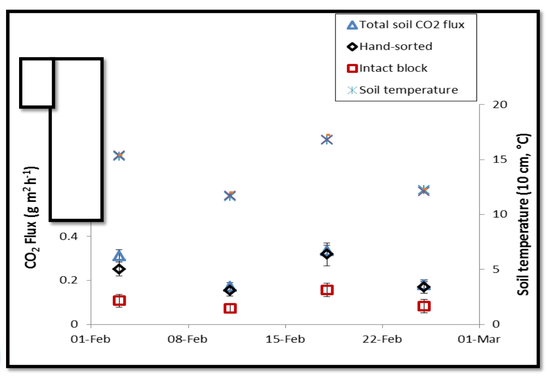

Fig. 4: Root exclusion bags results in February 2017

MAIN RESULTS

The Linear regression between root quantity and CO_2 flux had a slope of 0.08±0.04 and an intercept (assumed Rh) of 0.25±0.10 g CO_2 m^{-2} h^{-1} (Fig. 2, Table 1). The regression function from the lab incubation was: CO_2 flux =0.21*exp(-0.5*((temperature-49.2)/15.7)^2 + ((moisture-34.7)/19.2)^2)) (Fig. 3). The root exclusion bags with intact soil blocks had fluxes 47% lower than the root exclusion bags with hand-sorted roots on average (Fig. 4). On a yearly average the rate of fresh litter decomposition was approximately equal to the litterfall. Thus, the C emission from litter was estimated as 1.5±0.2 Mg CO_2-C ha^{-1} y^{-1} (Fig 5 & 6). Overall, the estimated Rh were 6.0±2.4, 0.4--1.9, 5.3±0.4 and 2.5 ±0.3 Mg CO_2-C ha^{-1} y^{-1} for the regression between root mass and derived CO_2, the incubations with soil microcosm cores, the intact blocks root exclusion bags and the hand-sorted root exclusion bags, respectively (Table 2).

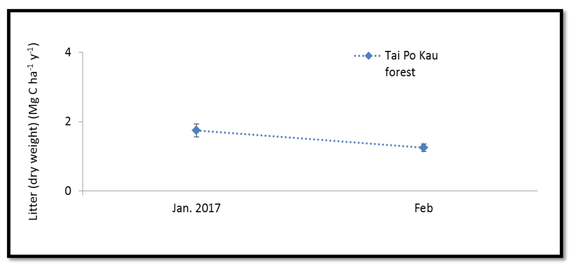

Fig. 5: Litterfall in January and February 2017

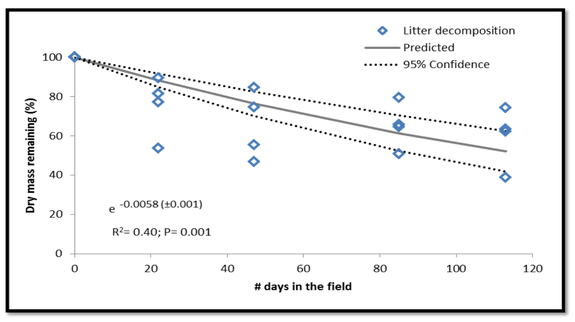

Fig. 6: Litterfall decomposition rate fall-winter 2016-2017

Table 1. Linear regression report between root quantity[a] and CO_2 flux[b]

Parameter	Value ($g\ m^2\ h^{-1}$)	SE[c]	t value	P value
Intercept[b]	0.25	0.10	2.50	0.02
Slope[b]	0.08	0.04	2.31	0.03

Overall r^2 of the linear regression: 0.21.
[a] root quantity in unit of milligram, small (radius between 0.1-0.5 cm) dried roots (60°C) per cm^3 of soil.
[b] CO_2 flux in unit of gram per m^2 per second.
[c] SE, standard error.

Table 2. Comparison of heterotrophic respiration assessment methods

Method	Rh flux[a]	Rs flux[b]	Rh / Rs
	----------Mg.CO_2–C ha^{-1} y^{-1}--------		--- % ---
Root regression	6.0 (2.4)	11.1 (1.0)	54 (41)
Soil cores incubation	0.4-1.9[c]		8-17[d]
Hand-sorted root exclusion bags	5.3 (0.4)	6.0 (0.3)	89 (1)
Intact root exclusion bags	2.5 (0.3)	6.0 (0.3)	42 (1)

Values are means and standard error, n = 22 for the root regression, n = 47 for soil incubation, n = 28 for both root exclusion bags techniques.
[a] Rh, heterotrophic respiration.
[b] Rs, total soil flux taken alongside the Rh flux.
[c] flux range at temperature between 14°C and 26°C.
[d] Calculated as Rh from incubation at 14°C and 26°C divided by field Rs at 14°C and 26°C respectively.

CONCLUSION

Results from field experiments exhibited a wide range of potential Rh (i.e. between 2.5 and 6.0 Mg CO_2-C ha^{-1} y^{-1}). In turn, this would complicate assessments of net C balance in this forest. No data is currently available regarding the total annual life biomass growth (LBG) (i.e. including root and above-grown biomass) at our site but as comparison, in a similar subtropical secondary forest (i.e. Gutianshan, southeast China) the annual LBG was assessed as 4.4±0.5 Mg ha^{-1} y^{-1} (Lin *et al.*, 2015).

Accordingly, depending on which Rh method is selected our study site could either be a net source or sink of C. Further study should also use δ ^{13}C natural abundance technique to compare with the traditional methods of Rh estimations.

The soil core incubation clearly produced underestimation of Rh likely because only 5 cm depth of soil cores were used and in the field the depth of the A horizon is around 15 cm. Further experiments with deeper soil cores are required to assess the usefulness of this method.